

1 IMAGE PROCESSING METHOD, RELATIVE DENSITY DETECTING METHOD  
2 AND IMAGE PROCESSING APPARATUS

3 FIELD OF THE INVENTION

4 The present invention relates to an image processing  
5 method and an apparatus thereof, which binarize a multi-  
6 valued image having depth, more particularly to an image  
7 processing method and an apparatus thereof, which exert per-  
8 formance for cutting out characters and the like.

9 BACKGROUND OF THE INVENTION

10 Recent years, a digital camera and so on have been  
11 developed, thus a request has been increased such that a  
12 large number of images, each of which includes a large num-  
13 ber of character images such as those on a white board used  
14 at a conference and on a time table, should be taken into  
15 photographs and stored, and later, character information and  
16 the like should be read out from the photograph information.  
17 Such a photograph image by a digital camera is a multi-  
18 valued image having depth. If image information of the  
19 multi-valued image is stored as it is and outputted accord-  
20 ing to needs, it is possible to read out the character  
21 information and the like from the photograph information of  
22 the multi-valued image.

23 However, the multi-valued image has a large amount of  
24 information, and storing the image information requires an  
25 enormous amount of memories. For a request to simply read a  
26 character, it is not preferable that the multi-valued image

1 is stored in memories as it is, and it is desirable that  
2 this multi-valued image is binarized to be stored in the  
3 memories. Such binarization of a multi-valued image having  
4 a depth is required for not only the foregoing example but  
5 also various other applications. For example, the binariza-  
6 tion is required for the case where an image is reduced in  
7 size to be stored, the case of performing pre-processing  
8 made for recognizing an object in an image such as a charac-  
9 ter, the case of obtaining a special image processing effect  
10 (such as a woodcut print image) and so on. As principal  
11 binarization methods, there have conventionally existed a  
12 simple binarization method, an edge emphasis binarization  
13 method, a binarization method designed to pursue photograph  
14 quality as much as possible by using a binary printer driver  
15 program and so on.

16 Moreover, in a gazette of Japanese Patent Laid-Open No.  
17 Sho 63-108470, in consideration of a defect that the sphere  
18 of characters or figures whose binarized images may be suf-  
19 ficient is stored as multi-valued data, a technology is  
20 disclosed, in which information for classifying spheres into  
21 respective spheres to be saved as binary data and multi-  
22 valued data is added to image data and stored, thus the  
23 image data is stored in a small volume. Furthermore, in a  
24 gazette of Japanese Patent Laid-Open No. Hei 5-225388, a  
25 technology is disclosed, in which each pixel is filtered  
26 depending on a change of image densities of pixels existing  
27 on a periphery thereof to smoothen and thin image data, thus  
28 pre-processing is executed for enhancing clearness of an  
29 image to perform character recognition and so on.

30 However, the simple binarization method as described  
31 above is hardly used actually, though it is very simple.

1 For example, if in an image, there are dark and bright por-  
2 tions that are mixed with each other, it often occurs that a  
3 density of a character existing in the bright portion is  
4 brighter than a background in the dark portion. For this  
5 reason, with this simple binarization method, there remain  
6 unsolved problems that an outline of a character or an  
7 object in the bright portion or the like is faded and that  
8 an outline of a character or an object in the dark portion  
9 or the like turns solid black together with a background.  
10 Moreover, the edge emphasis binary method cannot deal with a  
11 character having, for example, a blurred outline, therefore  
12 this method cannot be used for character recognition and the  
13 like. Furthermore, the binarization method designed to pur-  
14 sue photograph quality as much as possible by using a binary  
15 printer driver program provides the most natural image  
16 exhibiting good quality when viewed as a photograph by a  
17 person, but this method is not suitable for character recog-  
18 nition and cannot be used for the purpose of reducing a data  
19 volume to a great extent. Furthermore, in the prior arts  
20 described in the gazettes of Japanese Patent Laid-Open No.  
21 Sho 63-108470 and Hei 5-225388, a calculation amount is  
22 enormous and image processing to a great extent is required.  
23 Accordingly, the image processing using the binarization  
24 methods cannot be achieved with a simple system constitution  
25 by these prior arts, and it is difficult to attain high-  
26 speed processing therewith.

## 27 SUMMARY OF THE INVENTION

28 The present invention was made in order to solve the  
29 forgoing technical subjects. An aspect of the present

1 invention is to provide an image processing apparatus, which  
2 cut out, for example, a character and the like written with  
3 a pen and so on, the character being relatively darker than  
4 a background, at a high speed.

5 Another aspect of the present invention is to provide  
6 an image processing apparatus and the like, which emphasize  
7 an object without performing character recognition to com-  
8 press an image size without damaging understandability of  
9 the object.

10 It is still another aspect of the present invention to  
11 obtain binary data, which has a small number of step differ-  
12 ences and is smooth and high quality, even in the case where  
13 a background density is referred in an attempt of high-speed  
14 processing.

15 In order to achieve the foregoing aspects, according to  
16 the present invention, an image processing system used for  
17 pre-processing for cutting out a character and the like is  
18 provided, in which attention is paid to that a character  
19 written with a pen and so on is relatively darker than a  
20 background, a relative density of such a character to a  
21 periphery thereof is obtained and then the obtained relative  
22 density is binarized, and thus an object such as a character  
23 is emphasized and a background is brightened. Specifically,  
24 an image processing method, to which the present invention  
25 is applied, comprises the steps of: meshing an inputted  
26 image into sub images, each of which has a specified size  
27 and, for example, has a rectangular area to divide the  
28 inputted image into pixel groups; calculating a pixel group  
29 density for each of the divided pixel groups; and calculat-  
30 ing an output value of a certain watched pixel based on an  
31 absolute density of the watched pixel and a relative density

1 for the watched pixel, the relative density being calculated  
2 based on the pixel group density of the pixel group, to  
3 which the watched pixel belongs, and the pixel group density  
4 of the pixel group adjacent to the pixel group, to which the  
5 watched pixel belongs, among the pixel groups in the image.

#### 6 BRIEF DESCRIPTION OF THE DRAWINGS

7 For a more complete understanding of the present inven-  
8 tion and the advantages thereof, reference is now made to  
9 the following description taken in conjunction with the  
10 accompanying drawings.

11 Fig. 1 is an explanatory view showing an entire consti-  
12 tution of an image processing apparatus according to this  
13 embodiment.

14 Fig. 2 is a flowchart explaining a processing flow of  
15 an image processing system according to this embodiment.

16 Fig. 3 is a view showing a constitution of a function  
17 used in this system.

18 Figs. 4 (a) and 4 (b) are views respectively showing an  
19 idea when obtaining a relative value and a trapezoidal func-  
20 tion when obtaining a weight coefficient.

21 Figs. 5 (a) to 5 (d) are views showing image histograms  
22 representing the functions used in this system shown in Fig.  
23 3.

24 Figs. 6 (a) and 6 (b) are views showing examples of  
25 image processing performed for images of time tables photo-  
26 graphed by a digital camera.

27 Figs. 7 (a) and 7 (b) are views showing examples of  
28 image processing performed for the images of the time tables  
29 photographed by a digital camera.

1 Figs. 8 (a) and 8 (b) are views showing examples of  
2 image processing performed for photographs of a dining table  
3 taken by a digital camera.

4 Fig. 9 is a view showing an example of image processing  
5 performed for the photograph of the dining table taken by a  
6 digital camera.

7 DESCRIPTION OF THE INVENTION

8 Herein, "pixel group density" is a concept including  
9 not only an average density of a pixel group described in  
10 the embodiment but also a density of a typical pixel, for  
11 example, a typical density in a pixel range having the larg-  
12 est number of pixels. In this case, the typical density is  
13 obtained by setting a specified number of density ranges and  
14 obtaining a number of pixels entering each of the ranges.

15 Herein, the relative density may be calculated by use  
16 of an influence degree calculated based on a distance from  
17 the watched pixel and the pixel group, to which the watched  
18 pixel belongs, to the pixel group adjacent to the pixel  
19 group, each of the adjacent pixel group being located on and  
20 under and at the right and left of the pixel group. Moreo-  
21 ver, in the step of detecting the pixel group densities, an  
22 average density of the divided pixel group may be  
23 calculated, and the relative density may be calculated by  
24 multiplying the respective average densities of the pixel  
25 group, to which the watched pixel belongs, and of the pixel  
26 group adjacent to the pixel group, to which the watched  
27 pixel belongs, by the respective influence degrees. Fur-  
28 thermore, the relative density may be calculated based on an  
29 influence degree obtained by a trapezoidal function

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1 representing a positional relation between a coordinate  
2 position of the watched pixel and the pixel group adjacent  
3 to the pixel group, to which the watched pixel belongs.  
4 Conventionally, it has taken an enormous processing time to  
5 calculate an average density of a periphery of a pixel, for  
6 example, of the vicinity of  $N \times N$ , for each pixel in which a  
7 relative density thereof is obtained. However, with the  
8 above-described constitution, it is possible to execute  
9 high-speed processing and to obtain an output image with a  
10 quality hardly deteriorated.

11 Moreover, if the output value is calculated only with  
12 the relative value, for example, it may sometimes occur that  
13 values in both an entirely bright portion and an entirely  
14 dark portion are equal to each other. In this case, an  
15 image of a bright portion may be black, and an image of a  
16 dark portion may be white. However, in the step of calcu-  
17 lating this output value, the relative and absolute  
18 densities may be weighted to calculate the output value,  
19 thus it is possible to emphasize an object while maintaining  
20 a feature of an original image.

21 On the other hand, according to the present invention,  
22 a relative density detecting method for detecting a relative  
23 density of a watched pixel constituting an inputted image  
24 comprises the steps of: dividing the image into pixel  
25 groups, each of which has a specified size; detecting a  
26 pixel group density for each of the divided pixel groups;  
27 extracting positional information for the watched pixel in a  
28 pixel group including the watched pixel; and detecting a  
29 relative density of the watched pixel based on the pixel  
30 group density and the positional information.

1           Moreover, an absolute density of this watched pixel may  
2 be detected, and a relative density may be detected, which  
3 is obtained by adding a value obtained by multiplying a  
4 pixel group density by a weight of positional information to  
5 the detected absolute density. Thus, a step difference does  
6 not occur in a portion in which a density varies smoothly,  
7 and it is possible to represent a smooth density change in  
8 the output image.

9           Furthermore, a weight of this positional information  
10 may be calculated by applying a trapezoidal function repre-  
11 senting a positional relation between a position coordinate  
12 of the watched pixel and the pixel group adjacent thereto to  
13 extract this positional information. In such a manner, sim-  
14 plifying of the calculation is enabled, and this is  
15 preferable in that a scale of image processing can be made  
16 small and a processing speed can be accelerated.

17           Moreover, in order to achieve the foregoing aspects,  
18 according to the present invention, an image processing  
19 apparatus comprises: pixel group dividing means for dividing  
20 an inputted image into pixel groups, each of which has a  
21 specified size; pixel group density detecting means for  
22 detecting a pixel group density for each of the pixel groups  
23 divided by the pixel group dividing means; weight deciding  
24 means for deciding each weight of the pixel groups adjacent  
25 to the pixel, to which a watched pixel belongs, based on a  
26 position of the watched pixel to be outputted; watched pixel  
27 density detecting means for detecting a density of the  
28 watched pixel; and relative density calculating means for  
29 calculating a relative density of the watched pixel based on  
30 a detected density of the watched pixel, a pixel group



1 density of the detected pixel group and a decided weight of  
2 the pixel group.

3       Herein, the image processing apparatus may further com-  
4 prise output density calculation means for calculating an  
5 output density by performing predetermined weighting for the  
6 density of the watched pixel detected by the watched pixel  
7 density detecting means and the relative density calculated  
8 by the relative density calculating means. With such a con-  
9 stitution, for example, by properly executing weighting  
10 based on the rule of thumb, emphasis of an object and out-  
11 putting of a binarized image added properly with a feature  
12 of the original image are enabled.

13       Moreover, this pixel group dividing means may roundly  
14 divide an inputted image into meshes, each of which has I  
15 pixels×J pixels (I, J: integers). With such a constitution,  
16 this is preferable in that calculation for a background den-  
17 sity can be executed at a high speed. Furthermore, this  
18 weight deciding means may comprise a table look-up for  
19 deciding weights of each pixel groups adjacent to a pixel  
20 group, to which the watched pixel belongs, based on a coor-  
21 dinate position of the watched pixel. In this case,  
22 specifically, the pixel groups are located at the right and  
23 left of the pixel group, to which the watched pixel belongs,  
24 and/or on and under the pixel group, to which the watched  
25 pixel belongs. Still further, this weight deciding means  
26 may add weights of pixel groups located at the right and  
27 left of the pixel group and adjacent to the same, to which  
28 the watched pixel belongs, to obtain a sum of 1, and/or may  
29 add weights of pixel groups located on and under the pixel  
30 group and adjacent to the same, to which the watched pixel  
31 belongs, to obtain a sum of 1. With the above-described

1 constitution, a simple function can be applied to the meshes  
2 located on and under and at the right and left of the pixel  
3 group, to which the watched pixel belongs, that is, adjacent  
4 thereto. Thus, it is possible to obtain a smooth and high-  
5 quality binarized image.

6 Furthermore, according to the present invention, an  
7 image processing apparatus for converting image data, which  
8 includes a specified object photographed by a digital  
9 camera, into a binarized image, may comprise: a meshing unit  
10 for meshing the entire image data into sub images; an aver-  
11 age density detection unit for detecting an average density  
12 of each of the sub images meshed by the meshing unit; and a  
13 density detection unit for detecting a density of a pixel  
14 constituting the object. In this case, a binarized image,  
15 in which an outline of the object is emphasized, may be gen-  
16 erated based on a detected density of the pixel, an average  
17 density of the sub image, to which the pixel belongs, and an  
18 average density of the sub image adjacent to the certain sub  
19 image. With such a constitution, it is possible to obtain a  
20 high-quality binarized image at a high speed, and even in  
21 the case of compressing an image size, it is possible to  
22 obtain a binarized image, which can bear comparison with the  
23 multi-valued image in readability of an object such as a  
24 character.

25 DETAILED DESCRIPTION OF THE ADVANTAGEOUS EMBODIMENT

26 An embodiment of the present invention will be  
27 described in detail with reference to the accompanying draw-  
28 ings below.

Fig. 1 is an explanatory view showing an entire constitution of the image processing apparatus according to this embodiment. This image processing apparatus can be constituted as software, for example, in a personal computer, or can be constituted as hardware or software, for example, in a digital camera. Moreover, this image processing apparatus can be applied as an apparatus of cutting out a character as pre-processing for a character recognition apparatus. A reference numeral 11 denotes an image data input unit for inputting color image data of R (red), G (green) and B (blue), and a numeral 12 denotes a gray conversion unit for converting color image data inputted from the image data input unit 11 into multi-valued gray image data. Image data inputted to this image data input unit 11 is, for example, image data read out from an optical image reading apparatus such as a picked-up image data with a digital camera, and image data read out from a scanner, which is equipped with a line sensor in a main scanning direction and scans an image in a sub scanning direction to read an image. In this gray conversion unit 12, the existing gray conversion system can be employed, in which, for example, each image data of R, G and B is subjected to gray conversion and the converted image data are added to convert the same into gray image data having 256 gray scales from 0 to 255 gray scales. Moreover, the image processing may be individually performed for each of color signals R, G and B to calculate output densities thereof, thus adding the converted image data finally. Furthermore, in the case where the gray image data rather than the color image data is inputted, the gray conversion unit 12 may be omitted, and the image processing may be performed based on this gray image data.

A reference numeral 13 denotes a meshing unit for meshing the gray image data (M pixels×N pixels) converted by the gray conversion unit 12 to sub images, each of which has I pixels×J pixels, for example, 10 pixels×10 pixels. A numeral 14 denotes an average density detection unit for obtaining an average density in each of the meshes (sub images) meshed by the meshing unit 13. A numeral 15 denotes an average density storage unit for respectively storing the average densities obtained by the average density detection unit 14. A numeral 16 is a watched pixel position detection unit for detecting that a watched pixel exists in a mesh located in an i-th column and an j-th row, for example, from a fact that the watched pixel is a pixel in m-th column and n-th row, or contents meshed by the meshing unit 13 and the like. A numeral 17 denotes an absolute density storage unit for storing a density (absolute density) of each of the pixels including the watched pixel.

A reference numeral 18 denotes a watched pixel weight coefficient storage unit for storing an influence degree (relative relation) for meshes located on and under and at the right and at the left of the watched pixel and at as a weight coefficient. For example, if the meshed sub image is constituted of 10 pixels×10 pixels, the weight coefficient is stored in a table of the watched pixel weight coefficient storage unit 18 as, for example, ten coefficients, that is, 0.05, 0.15... 0.85, 0.95. A numeral 19 denotes a relative density calculation unit for calculating a relative density for each watched pixel in consideration of brightness in the periphery of the watched pixel based on each of the data from the average density storage unit 15 and the absolute density storage unit 17 and a weight coefficient read out

1 from the watched pixel weight coefficient storage unit 18.  
2 A numeral 20 denotes a weight coefficient storage unit for  
3 storing weight values of the relative and absolute densities  
4 such as a value based on the rule of thumb, for example,  
5 that a weight of the absolute value is reduced to  
6 one-eighth. A numeral 21 denotes an output density calculation unit for calculating an output density from the  
7 relative density calculated by the relative density calculation unit 19 based on a weight obtained by the weight  
8 coefficient storage unit 20 and the absolute density of the  
9 watched pixel read out from the absolute density storage  
10 unit 17. A numeral 22 denotes an image data output unit for  
11 outputting an image having a final density calculated by the  
12 output density calculation unit 21 to a next step thereof  
13 such as a memory and printing devices.

16 Fig. 2 is a flowchart explaining a processing flow of  
17 the image processing system according to this embodiment.  
18 First, from a result of the gray conversion unit 12 and the  
19 like, a gray image having M pixels×N pixels is obtained  
20 (step 101). This obtained gray image is meshed into sub  
21 images having, for example, 10 pixels×10 pixels, to form I×J  
22 meshes (pixel group) (step 102). Next, an average density  
23 in each of the meshes is obtained. (step 103). For example,  
24 if the gray image is meshed into 10 pixels×10 pixels, an  
25 average value (density) of 100 pixels (=10 pixels×10 pixels)  
26 is calculated. Then, an absolute density of each watched  
27 pixel is obtained (step 104), and by using this absolute  
28 density, a relative density to five meshes (mesh including  
29 watched pixel itself, two meshes on and under the center  
30 mesh and two meshes at the right and left of the center  
31 mesh) is obtained for each watched pixel (step 105).

1     Thereafter, a final density is decided by a function added  
2     with the absolute and relative densities for each watched  
3     pixel (step 106).

4             Next, description will be made in detail for a function  
5     used in this system.

6             Fig. 3 shows a constitution of the function used in  
7     this system.  $[P]_{mn}$  shows a final value (density) of a pixel  
8     located in the  $m$ -th column and the  $n$ -th row. This final  
9     value is schematically calculated from a value added with a  
10    constant  $C$ , a value added with the absolute value and a  
11    value added with the relative value. Specifically, in an  
12    equation shown in Fig. 3, a first term of a right side  
13    thereof represents a constant term, a second term thereof  
14    represents the one obtained by multiplying the absolute  
15    value by  $\alpha$ , and a third term thereof represents the one  
16    obtained by multiplying the relative value by  $\beta$ . This third  
17    term of the right side is added with a relative value given  
18    in consideration of a mesh itself (in an  $i$ -th column and a  
19     $j$ -th row) and meshes on and under the mesh and a relative  
20    value given in consideration of the mesh itself and two  
21    meshes at the right and left sides. Herein, if the final  
22    value is decided only with the relative values, for example,  
23    it may sometimes occur that values in both an entirely  
24    bright portion and an entirely dark portion are equal to  
25    each other. Thus, there exists a possibility of a result  
26    which is occurred to be a different image from an actual  
27    image. For example, an image of a bright portion may be  
28    black, and an image of a dark portion may be white. For  
29    this reason, this system is constituted such that the final  
30    value can be decided by adding the absolute value.  
31    Moreover, the absolute value  $P_{mn}$  of the watched pixel is

multiplied by the weight coefficient  $\alpha$ . In this case, experientially, the value  $\alpha$  is preferably reduced to about one-eighth. Furthermore, the final value may sometimes fall in a minus if the absolute value is made small when the final value is calculated with the relative value. Therefore, as the constant  $C$ , a value, which is decided experientially so that the final value is not to fall in a minus, is employed. Note that in this function, an average density of a mesh image in the  $i$ -th column and the  $j$ -th row, to which the watched pixel belongs, is represented as  $S_{i,j}$ , an average density of a mesh image located thereon is represented as  $S_{i-1,j}$ , an average density of a mesh image located thereunder is represented as  $S_{i+1,j}$ , an average density of a mesh image located at the left thereof is represented as  $S_{i,j-1}$ , and an average density of a mesh image located at the right thereof is represented as  $S_{i,j+1}$ . Furthermore, a weight coefficient of the mesh on the watched pixel is represented as  $d_1$ , a weight coefficient of the mesh at the left thereof is represented as  $d_2$ , a weight coefficient of the mesh at the right thereof is represented as  $d_3$ , and a weight coefficient of the mesh thereunder is represented as  $d_4$ .

In this function shown in Fig. 3, for example, parameters may be designated as follows:

In the original image:  $C=0$ ,  $\alpha=1$ ,  $\beta=0$ ;

in the image only having the relative value:

$C=\text{plus value}$ ,  $\alpha=0$ ,  $\beta=\text{plus value}$ ; and

in the image added with the absolute value and the relative value:

$C=\text{plus value}$ ,  $\alpha=\text{plus value}$ ,  $\beta=\text{plus value}$ .

1 With the above designation of the parameters, various  
2 images including an image enlarged in contrast can be formed  
3 at a high speed.

4 Figs. 4 (a) and 4 (b) are views respectively showing an  
5 idea when obtaining the relative value and a trapezoidal  
6 function when obtaining the weight coefficient. In Fig. 4  
7 (a), as explained with reference to Fig. 3, an average den-  
8 sity of a mesh image in the  $i$ -th column and the  $j$ -th row, to  
9 which the watched pixel belongs, is represented as  $S_{i,j}$ , an  
10 average density of a mesh image located thereon is repre-  
11 sented as  $S_{i-1,j}$ , an average density of a mesh image located  
12 thereunder is represented as  $S_{i+1,j}$ , an average density of a  
13 mesh image located at the left thereof is represented as  
14  $S_{i,j-1}$ , and an average density of a mesh image located at the  
15 right thereof is represented as  $S_{i,j+1}$ . In this example, the  
16 watched pixel is located at the upper right position in the  
17 mesh image in the  $i$ -th column and the  $j$ -th row. The influ-  
18 ence degrees (weights) received from the mesh images by the  
19 watched pixel are as follows. The weight is 1 in the mesh  
20 in the  $i$ -th column and the  $j$ -th row. Since the watched  
21 pixel is located close to the mesh located on the mesh, to  
22 which the watched pixel belongs, the weight  $d_1$  is equal to  
23 0.85 in the mesh in the  $i$ -th column and the  $j$ -th row. The  
24 weight  $d_4$  is equal to 0.15 in the mesh thereunder. The  
25 weight  $d_2$  is equal to 0.35 in the mesh at the left thereof.  
26 The weight  $d_3$  is equal to 0.65 in the mesh at the right  
27 thereof. Herein,  $d_1+d_4=1$  and  $d_2+d_3=1$ , and the mesh has 10  
28 pixels $\times$ 10 pixels. Therefore, in consideration of the cen-  
29 ters of the respective pixels, the respective weight values  
30 can take ten values as described above, that is, 0.05,  
31 0.15,...0.85 and 0.95.



1 The relation of the weight coefficients when obtaining  
2 the relative value can be easily explained with reference to  
3 the trapezoidal function shown in Fig. 4 (b). In Fig. 4  
4 (b), an example of obtaining the weights of the mesh images  
5 located at the right and left of the mesh, to which the  
6 watched pixel belongs, by use of the positional relation in  
7 the X-coordinate is illustrated. The upper side of this  
8 trapezoidal function shows a position of the sub area (mesh  
9 image) in the i-th column and the j-th row in which the  
10 watched pixel exists, and a length thereof is 1. The  
11 hypotenuses slant from both ends of the upper side downward  
12 to the right and left directions have a slant, which has a  
13 width of 1 and a height of 1.

14 Now, the X-coordinate of the watched pixel is assumed  
15 as  $nc$ , the X-coordinate of the left end of the watched pixel  
16 in the mesh is assumed as  $nl$  (X-coordinate of the pixel at  
17 the left end in the mesh-0.5), and the size of the mesh  
18 image is assumed as  $Sz$ . In this case, for example, the  
19 weight coefficient  $d_2$  of the mesh at the left of the mesh in  
20 the i-th column and the j-th row and the weight coefficient  
21  $d_3$  of the mesh at the right of the mesh in the i-th column  
22 and the j-th row can be obtained in the following equations.

$$d_2 = 1 - (nc - nl) / Sz$$

$$d_3 = (nc - nl) / Sz$$

25 Results obtained from the above equations can be also  
26 obtained from the trapezoidal function shown in Fig. 4 (b),  
27 that is,  $d_2$  can be obtained from the left hypotenuse and  $d_3$   
28 can be obtained from the right hypotenuse. Note that, simi-  
29 larly to the above, the weight coefficients  $d_1$  and  $d_4$  of the  
30 mesh images on and under the center mesh can be obtained  
31 from the positional relation of the Y-coordinate.

1 In the foregoing manner, the weight coefficients are  
2 previously calculated in this embodiment, and can be easily  
3 obtained by a table look-up while calculating  $[P]_{mn}$ . By  
4 obtaining the weight coefficients with the above-described  
5 system, background values as bases for comparison among the  
6 respective pixels at the positions in the meshes can be made  
7 to differ delicately from one to another, thus it is possi-  
8 ble to obtain a smooth image without suddenly bringing about  
9 a great change of the image at a boundary of the meshes.

10 Note that although the average density of the four mesh  
11 images located on and under and at the right and left of the  
12 mesh in the  $i$ -th column and the  $j$ -th row is used as the  
13 relative density of the meshes adjacent to each other, the  
14 average density of the slant images may be further added as  
15 long as the processing is permitted to fall a little compli-  
16 cated.

17 Figs. 5 (a) to 5 (d) are views showing image histograms  
18 representing the functions used in this system shown in Fig.  
19 3. Fig. 5 (a) shows an original histogram. Fig. 5 (b)  
20 shows a histogram where the absolute value in the original  
21 histogram of Fig. 5 (a) is multiplied by  $a$  (herein, by  $1/8$ ).  
22 Fig. 5 (c) is a histogram where the relative value obtained  
23 by the algorithm as described above is added to the histo-  
24 gram of Fig. 5 (b). Under the condition that the relative  
25 value is simply added, the histogram may include a minus  
26 value in some cases. Therefore, in this embodiment, the  
27 constant  $C$  is added as shown in Fig. 5 (d) to jack up the  
28 histogram, thus adjusting an output value.

29 Next, description will be further made for this embodi-  
30 ment with reference to output examples.

1 Figs. 6 (a) and 6 (b) and Figs. 7 (a) and 7 (b) show  
2 examples of image processing performed for images of time  
3 tables photographed by a digital camera. Note that in these  
4 views, there appear images, which are against the present  
5 applicant's will due to conversion at the time of filing the  
6 present invention. Herein, the parameters of the function  
7 shown in Fig. 3 are set as follows.

8 constant  $C=64$ ,  $\alpha=1/8$ ,  $\beta=1$

9 And the mesh size is set as  $Sz=8$ . Fig. 6 (a) shows an image  
10 obtained by printing an 8-bit multi-valued image so as to  
11 have high image quality as possible by a printer driver.  
12 From this image, it is possible to read time data such as a  
13 character 51 and the like. However, a data volume thereof  
14 is 51.5kB (tif file compressed with JPEG), which is consid-  
15 erably large. Fig. 6 (b) shows an image obtained by  
16 subjecting the original image to the conventional simple  
17 binarization. In this case, a data volume thereof is  
18 reduced to 5.0kB (tif file compressed with G4MMR), which is  
19 small. However, in this case, there are many characters,  
20 which can not be read. For example, it is difficult to  
21 determine the character 51. Moreover, a background 52 also  
22 appears differently from an actual image thereof to a great  
23 extent. On the other hand, Fig. 7 (a) shows a binarized  
24 image obtained by performing relative value calculation  
25 thereto not by use of the above-described trapezoidal func-  
26 tion but by use only of the mesh, to which the watched pixel  
27 belongs. In this case, a data volume thereof is 7.7kB  
28 (G4MMR), which is small, and it is possible to read the  
29 character 51 precisely. Moreover, a background 52 expresses  
30 a feature of an actual image thereof. However, the back-  
31 ground 52 is affected by the influence of the boundary of

1 the meshes, hence there are some places where unnatural rug-  
2 gedness occurs. Fig. 7 (b) shows a binarized image obtained  
3 by further performing relative value calculation by use of  
4 slope functions of the trapezoids located on and under and  
5 at the right and left of the certain mesh. Herein, a data  
6 volume thereof is 9.7kB (G4MMR), which is small. Moreover,  
7 ruggedness on the background 52 disappears, hence a consid-  
8 erably natural binarized image is achieved. Furthermore, it  
9 is possible to determine the character 51 sufficiently.  
10 Accordingly, obtained readability of the character 51 can  
11 even bear comparison with the multi-valued image shown in  
12 Fig. 6 (a).

13 Figs. 8 (a) and 8 (b) and Fig. 9 are views showing  
14 examples of image processing performed for photographs of a  
15 dining table taken by a digital camera. Note that, also in  
16 these views, there appear images, which are against the pre-  
17 sent applicant's will due to conversion at the time of  
18 filing the present invention. Fig. 8 (a) is a binarized  
19 image obtained by processing the taken image into 8-bit  
20 multi-valued image and then subjecting the 8-bit multi-  
21 valued image to an error diffusion method as a prior art.  
22 In this case, an image size thereof is 62.0kB (G4MMR), which  
23 is large. Fig. 8 (b) shows an image obtained by subjecting  
24 the image of Fig. 8 (a) to the simple binarization. In this  
25 case, an image size thereof is 5.7kB (G4MMR), which is  
26 small. However, the image is greatly defaced, and it is  
27 hardly possible to determine an outline thereof. On the  
28 other hand, Fig. 9 shows an image subjected to image proc-  
29 essing with the system according to this embodiment. In  
30 this case, an image size thereof is 15.0kB (G4MMR), which is  
31 relatively small. Moreover, it is possible to clearly

1 express existence of objects. Accordingly, an artistic  
2 image can be obtained, and it is possible to utilize the  
3 image as a rough copy for a woodcut print.

4 As described above, with the image processing method  
5 according to this embodiment, image processing is performed  
6 by properly combining the absolute value and the relative  
7 value, thus the image processing method can be used for  
8 various purposes such as pre-processing for cutting out an  
9 object including a character, storing memo data on a white  
10 board, a time table of a bus service and the like, making a  
11 rough copy for a woodcut print. With the image processing  
12 method, extraction of a character can be achieved with a  
13 high quality. Accordingly, it is possible to apply the  
14 image processing method, for example, to pre-processing for  
15 an automatic reading system of postal matters' addresses.  
16 Moreover, with this image processing method, it is possible  
17 to reduce an image size to about 1/5 compared with that of  
18 the 8-bit multi-valued image. Accordingly, a great effect  
19 can be obtained, for example, in the case where a large  
20 amount of images photographed by a digital camera are  
21 desired to be stored. Furthermore, since the image process-  
22 ing method is realized by use of a simple function, the  
23 image processing can be carried out at a high speed, and  
24 nevertheless, a binarized image having a high quality can be  
25 obtained.

26 Moreover, there may be provided a user interface for  
27 allowing the equation shown in Fig. 3 to change. Thus,  
28 adjustment can be performed so as to correspond to a charac-  
29 teristic of an image to be processed, for example, an image  
30 having overall a small (or large) contrast, an image having  
31 a character or an object desired to be determined, which has

1 an outline and the like close to (or sufficiently different  
2 from) a background thereof in density, and an image where  
3 black dots such as noises appeared on the surface of an  
4 object are apt to appear, the noise being occurred by an  
5 influence of the object or the background and not being  
6 desired by a user. Moreover, adjustment can be performed  
7 reflecting an effect intended by a user.

8 For example, the equation of Fig. 3 is assumed to be  
9 further converted as follows.

$$[P]_{mn} = C + (\alpha + \beta) P_{mn} - \beta (nS_{1j} + d_1 S_{1-1j} + d_4 S_{i+1j} \\ + d_2 S_{1j-1} + d_3 S_{1j+1}) / (n+2)$$

12 First, by changing the value C, brightness (density) of the  
13 overall image can be changed. Moreover, by changing the  
14 value  $\alpha$  to a sufficiently larger value in comparison with  
15 the value  $\beta$ , an image closer to the simply binarized images  
16 shown in Fig. 6 (b) and Fig. 8 (b) can also be obtained.  
17 Then, by changing the value n, the influence given to the  
18 relative value between the mesh including the watched pixel  
19 and the meshes adjacent thereto can be changed.

20 Furthermore, by reducing the mesh itself in size, the  
21 image is apt to be affected by the influence of the density  
22 change of the fine portions thereof. Accordingly, the image  
23 made to reflect the patterns and the like of the fine por-  
24 tions generated depending on a material of the object can be  
25 obtained.

26 Moreover, in the advantageous embodiment of the present  
27 invention, the influence degree of the meshes adjacent to  
28 each other has been described with reference to the linear  
29 function inversely proportional to the distance of the adja-  
30 cent meshes and the watched pixel. However, the influence  
31 degree can be calculated with reference to other functions

1 such as the multidimensional function and the trigonometric  
2 function.

3 As described above, according to the present invention,  
4 it is possible to cut out a character and the like at a high  
5 speed, which are written with a pen and so on the character  
6 being relatively darker than a background in a multi-valued  
7 image, to use the cutting-out of a character for pre-  
8 processing for character recognition and the like, to  
9 emphasize an object such as a character and a figure, and to  
10 compress an image size without damaging understandability of  
11 the object.

12 The present invention can be realized in hardware, soft-  
13 ware, or a combination of hardware and software. The present  
14 invention can be realized in a centralized fashion in one  
15 computer system, or in a distributed fashion where different  
16 elements are spread across several interconnected computer  
17 systems. Any kind of computer system - or other apparatus  
18 adapted for carrying out the methods described herein - is  
19 suitable. A typical combination of hardware and software  
20 could be a general purpose computer system with a computer  
21 program that, when being loaded and executed, controls the  
22 computer system such that it carries out the methods  
23 described herein. The present invention can also be embedded  
24 in a computer program product, which comprises all the fea-  
25 tures enabling the implementation of the methods described  
26 herein, and which - when loaded in a computer system - is  
27 able to carry out these methods.

28 Computer program means or computer program in the pre-  
29 sent context mean any expression, in any language, code or  
30 notation, of a set of instructions intended to cause a system  
31 having an information processing capability to perform a

1 particular function either directly or after conversion to  
2 another language, code or notation and/or reproduction in a  
3 different material form.

4 It is noted that the foregoing has outlined some of the  
5 more pertinent objects and embodiments of the present inven-  
6 tion. This invention may be used for many applications.  
7 Thus, although the description is made for particular  
8 arrangements and methods, the intent and concept of the  
9 invention is suitable and applicable to other arrangements  
10 and applications. It will be clear to those skilled in the  
11 art that other modifications to the disclosed embodiments can  
12 be effected without departing from the spirit and scope of  
13 the invention. The described embodiments ought to be con-  
14 strued to be merely illustrative of some of the more  
15 prominent features and applications of the invention. Other  
16 beneficial results can be realized by applying the disclosed  
17 invention in a different manner or modifying the invention in  
18 ways known to those familiar with the art.

19 Thus, although the advantageous embodiments of the pre-  
20 sent invention have been described in detail, it should be  
21 understood that various changes, substitutions and alterna-  
22 tions can be made therein without departing from spirit and  
23 scope of the invention as defined by the appended claims.